Converting 6inch Asphalt to a Soil Depth

The basic shielding calculation is:

$$I_f = I_0 e^{-\mu_L t}$$

Where I_f is the final intensity of radiation,
I_0 is the original intensity of radiation
μ_L is the linear attenuation coefficient of the material attenuating the radiation, and
t is the thickness of the attenuator

If we divide by I_0, we get the fraction of intensity that has been attenuated when passing through a specific absorber of a specific thickness (t).

$$\frac{I_f}{I_0} = e^{-\mu_L t}$$

If we use soil, the fraction of intensity equation would look like the following:

$$\frac{I_{f,soil}}{I_{0,soil}} = e^{-\mu_{L,soil} t_{soil}}$$

Likewise, if we use asphalt, the fraction of intensity equation would look like the following:

$$\frac{I_{f,asphalt}}{I_{0,asphalt}} = e^{-\mu_{L,asphalt} t_{asphalt}}$$

For Hunter's Point, we want to determine how much soil would give us the same fraction of intensity as 6inches of asphalt. To determine the depth of soil needed, we will set both the fraction of intensity of soil and asphalt equal to each other as followed:

$$e^{-\mu_{L,soil} t_{soil}} = \frac{I_{f,soil}}{I_{0,soil}} = \frac{I_{f,asphalt}}{I_{0,asphalt}} = e^{-\mu_{L,asphalt} t_{asphalt}}$$

If we cancel out the intensity fraction, this would give us:

$$e^{\mu_{L,soil} t_{soil}} = e^{\mu_{L,asphalt} t_{asphalt}}$$

To eliminate the exponential, we multiply each side by natural log of each side.

$$ln(e^{\mu_{L,soil}t_{soil}}) = ln(e^{\mu_{L,asphalt}t_{asphalt}})$$

This would give us:

$$\mu_{L,soil}t_{soil} = \mu_{L,asphalt}t_{asphalt}$$

If we solve to t_{soil}, this would give us the equation needed to determine the depth of soil needed to equal 6 inches of asphalt.

$$t_{soil} = \frac{\mu_{L,asphalt}t_{asphalt}}{\mu_{L,soil}}$$

In order to solve the above equation, we must know the linear attenuation coefficient for soil and asphalt. The linear attenuation coefficient is determined by specific energies. If we look at a lower energy such as 0.186MeV for Ra-226, we get the following

$$t_{soil} = \frac{\mu_{L,asphalt}t_{asphalt}}{\mu_{L,soil}}$$

where the $t_{asphalt}$=6 inches = 15.24 cm
$\mu_{L,asphalt}$ = 0.307 cm^{-1}
$\mu_{L,soil}$ = 0.195 cm^{-1}

$$t_{soil} = \frac{0.307\ cm^{-1} \times 15.24\ cm}{0.195\ cm^{-1}}$$

$$t_{soil} = 23.99$$

If we look at a higher energy such as 2.614MeV for Tl-208, we get the following:

$$t_{soil} = \frac{0.0916 cm^{-1} \times 15.24 cm}{0.0541\ cm^{-1}}$$

$$t_{soil} = 25.79$$

FINAL

BASEWIDE RADIOLOGICAL REMOVAL ACTION
ACTION MEMORANDUM – REVISION 2006
HUNTERS POINT SHIPYARD
SAN FRANCISCO, CALIFORNIA

April 21, 2006

DEPARTMENT OF THE NAVY
Naval Facilities Engineering Command, Southwest
San Diego, California

TABLE 1

RELEASE CRITERIA

Radionuclide	Surfaces			Soil[d] (pCi/g)				Water[h] (pCi/L)
	Equipment, Waste (dpm/100 cm²)[a]	Structures (dpm/100 cm²)[b]	Residual Dose (mrem/yr)[c]	Outdoor Worker (pCi/g)[e]	Residual Dose (mrem/yr)[c]	Residential (pCi/g)[e]	Residual Dose (mrem/yr)[c]	
Americium-241	100	100	18.7	5.67	0.8661	1.36	24.84	15
Cesium-137	5,000	5,000	1.72	0.113	0.2142	0.113	0.2561	119
Cobalt-60	5,000	5,000	6.01	0.0602	0.5164	0.0361	0.3918	100
Europium-152	5,000	5,000	3.21	0.13 [f]	0.5018	0.13 [f]	0.502	60
Europium-154	5,000	5,000	3.49	0.23 [f]	0.9593	0.23 [f]	0.9599	200
Plutonium-239	100	100	18.1	14.0	1.743	2.59	1.138	15
Radium-226	100	100	0.612	1.0[g]	6.342	1.0[g]	14.59	5[i]
Strontium-90	1,000	1,000	0.685	10.8	0.1931	0.331	1.648	8
Thorium-232	1,000	36.5	24.9	2.7	24.91	1.07 1.69	25	15
Tritium	5,000	5,000	0.00053	4.23	0.00179	2.28	0.05263	20,000
Uranium-235+D	5,000	488	25	0.398	0.178	0.195	0.8453	30

Notes: Risk 10^{-4} @ 25 mrems

[a] These limits are based on AEC *Regulatory Guide 1.86* (1974). Limits for removable surface activity are 20 percent of these values. Risk is still [illegible]

[b] These limits are based on 25 mrem/yr, using RESRAD-Build Version 3.3 or *Regulatory Guide 1.86*, whichever is lower.

[c] The resulting dose is based on modeling using RESRAD-Build Version 3.3 or RESRAD Version 6.3, with radon pathways turned off.

[d] EPA PRGs for two future-use scenarios.

[e] The on-site and off-site laboratory will ensure that the MDA meets the listed release criteria by increasing sample size or counting time as necessary. The MDA is defined as the lowest net response level, in counts, that can be seen with a fixed level of certainty, customarily 95 percent. The MDA is calculated per sample by considering background counts, amount of sample used, and counting time.

TABLE 1

RELEASE CRITERIA

[f] Based on EPA-decay corrected PRGs for commercial reuse and a previous action memorandum (TtEMI, 2000a, 2001).

[g] Limit is 1 pCi/g above background, per agreement with EPA.

[h] Release criteria for water have been derived from *Radionuclides Notice of Data Availability Technical Document*, (EPA, 2000) by comparing the limits from two criteria and using the most conservative limit.

[i] Limit is for total radium concentration.

AEC – Atomic Energy Commission
cm^2 – square centimeters
dpm – disintegrations per minute
EPA – U.S. Environmental Protection Agency
MDA – minimum detectable activity
mrem/yr – millirem per year
pCi/g – picocurie per gram
pCi/L – picocurie per liter
PRG – preliminary remediation goal
TtEMI – Tetra Tech EM, Inc.

Final

Remedial Design Package
Parcel B
(Excluding Installation Restoration Sites 7 and 18)

Design Basis Report
Remedial Action Monitoring Plan
Land Use Control Remedial Design
Preconstruction Operation and Maintenance Plan
Opinion of Probable Construction Cost

Hunters Point Shipyard
San Francisco, California

December 10, 2010

Prepared for:
Base Realignment and Closure
Program Management Office West
San Diego, California

Prepared by:
ChaduxTt, A Joint Venture of St. George Chadux Corp.
and Tetra Tech EM Inc.
1230 Columbia Street, Suite 1000
San Diego, California 92101

Prepared under:
Naval Facilities Engineering Command
Contract Number N62473-07-D-3213
Contract Task Order 0019

CHAD-3213-0019-0057

original well. New concrete pads and well boxes will be constructed flush to the completed cover surface using traffic-rated materials. Prior approval by the Contracting Officer and the FFA signatories for decommissioning and replacing monitoring wells will be required.

The locations of the existing wells are provided on Figures 4 and 5 of this report. Refer to the RAMP for detailed information about the groundwater monitoring wells.

3.2 DURABLE COVER

A durable cover is the remedy selected to prevent contact with COCs that may be present in soil over Parcel B as specified in the amended ROD (ChaduxTt 2009a). The remediation goals for soil, as developed in the amended ROD, are included in Table 2 to the DBR and serve as a portion of the basis of design for the remedy. The durable cover over the site will consist of one of the following, depending on location: asphalt pavement, a 2-foot-thick soil cover, or the existing building foundations. Repair of the existing AC surfacing over the site would constitute a durable cover; however, repair is assumed to not be practical, as described in Section 3.2.1.

The primary durable cover design criterion, as specified in the ROD, is to prevent human exposure to the potentially contaminated soil beneath (ChaduxTt 2009a). An asphalt pavement will extend between the existing buildings over the majority of the site to contain the currently exposed soils. The existing building foundations are also considered a component of the durable cover. The asphalt pavement cover and the existing building foundations prevent human contact with the potentially contaminated soil beneath. These covers are considered durable because they are non-erodible and would require deliberate and destructive actions to expose underlying soil.

A 2-foot-thick soil cover will be constructed along the southwestern property boundary. This cover meets the requirements of the approved ROD for protectiveness and durability and is based on discussions with the HPS Base Realignment and Closure Cleanup Team (BCT) throughout development of the ROD at Parcel B and other parcels at HPS (ChaduxTt 2009a). This thickness is based on the human health risk assessment completed for Parcel B (ChaduxTt 2007), which followed guidance from the U.S. Environmental Protection Agency (EPA) (1989) for differentiating exposure scenarios for surface and subsurface soils. The soil cover is considered durable because it is designed to resist erosion, prevents incidental human contact with underlying soil, and would require deliberate and destructive action to cause a breach.

Permeability of the durable cover is not a design consideration because the remaining metals in soil are not sufficiently mobile (based on more than 25 rounds of groundwater monitoring in some wells) to pose a risk to aquatic life in the bay. Therefore, infiltration of water through the cover is not a design consideration, and the durable cover is not designed to prevent infiltration of water.

A secondary criterion for the durable cover design is to reduce long-term maintenance and repair needs throughout the ongoing post-closure period that could expose the underlying soil. The durable cover is non-erodible or erosion resistant. Applied forces that could break down the cover include erosion by wind and storm water, vandalism, and climatic degradation. Traffic loading over the site is not specifically part of the design criteria in the ROD and the ARARs, but some light traffic is assumed. This DBR assumes that traffic and site access will be restricted as necessary to prevent damage to the asphalt pavement cover.

The non-erodible or erosion-resistant cover components over the site will vary as follows:

- New asphalt pavement will be constructed where the existing surface is a soil cover or where the existing asphalt pavement is beyond repair.
- A vegetated soil cover will be constructed along the southern (hillside) portion of the site.
- Existing buildings with concrete foundations, utilities, and other permanent structures will be repaired as needed to prevent human contact with underlying soil and incorporated in the final durable cover.

The asphalt pavement cover is described in Section 3.2.1 of this DBR. The soil cover is described in Section 3.2.2, and the existing building foundations are described in Section 3.2.3. The durable cover will cover all portions of Parcel B up to the shoreline revetment.

Figure 7 presents a conceptual cross section of the asphalt pavement and the soil covers, and Figures 8 and 9 show the final cover grade. The durable cover will extend over all portions of Parcel B between the site boundary and the shoreline revetment. The primary design criterion for the durable cover is to prevent human contact with the underlying soil. The presence of utility features under the durable cover does not inhibit the durable cover from meeting this criterion. Utility features will be left in place and the durable cover will be constructed over the utility feature or up to and around the feature. The construction contractor will have the option of removing utility features if desired for construction of the durable cover.

Any gradual degradation of the durable cover is addressed through O&M procedures that would occur before the effectiveness of the cover at preventing human contact with underlying soil would be reduced. Damage to the durable cover from earthquake shaking could breach the cover and expose the underlying material. Repair to the cover and emergency response actions are specified in the O&M plan included in this binder. Refer to Section 3.8 of the DBR for details on stability and seismic considerations.

Other types of covers may meet the performance requirements of the amended ROD; however, other cover types are not developed in this DBR. Other cover types proposed by the City and County of San Francisco are described briefly below (City and County of San Francisco Health Department 2009):

- (1) For any at-grade or below grade structures that will be required to undergo the San Francisco Department of Building Inspection (SFDBI) permit and approval process, any design that meets or exceeds the requirements of the San Francisco Building Code and is properly permitted and approved by the SFDBI will be adequate to serve as a cover as intended by the amended ROD. An approved building permit will serve as verification that an appropriate design has been developed.

- (2) For any street, sidewalk, concrete promenade, concrete boardwalk, or any soil covering that completely covers the soil and is constructed of asphalt or concrete or similar material and that is required to follow the SFDBI or San Francisco Department of Public Works (SFDPW) permit and approval process, any design which meets or exceeds the requirements of the San Francisco Building Code or the San Francisco Public Works Code and is properly permitted and approved by the SFDBI or SFDPW will be adequate to serve as a cover as intended by the amended ROD. An approved SFDBI or SFDPW permit will serve as verification that an appropriate design has been developed.

- (3) For any open space area, park, area with an above grade structure that leaves exposed and accessible soil underneath (for example, an elevated walkway or bridge), pathways made of removable paving stones, or any area that does not meet the definition of items 1 or 2 above, a design will be submitted that incorporates at least 2 feet of imported clean fill (meeting soil importation criteria) or similar materials. If the design does not include 2 feet of clean fill, an explanation of how the design provides equivalent or greater protection than 2 feet of clean fill will be submitted.

The other cover types listed above may be consistent with the SFRA redevelopment plans for the site; however, actual redevelopment plans have not been conclusively established. Development-related work plans will require FFA review and approval to ensure the protectiveness of the final covers ultimately selected.

The following sections describe the components of the durable cover developed in this DBR.

3.2.1 Asphalt Pavement Cover

A durable non-erodible asphalt pavement cover, consisting of a base course and an AC wear course surface, is presented in this RD as the remedy to prevent contact with COCs that may be present over most of Parcel B in accordance with the ROD (ChaduxTt 2009a). The primary criterion for the design of the asphalt pavement cover is to prevent contact with the potentially contaminated soil beneath. The secondary criterion for the design of the asphalt pavement is to withstand the applied forces that could break down the cover and reduce its effectiveness in preventing contact with the underlying soil. Applied forces that could breakdown the cover include erosion by wind and storm water, vandalism, and climatic degradation. Traffic loading over the asphalt pavement is not specifically part of the design criteria in the ROD and the ARARs, but light traffic is assumed. This DBR assumes that traffic will be restricted as necessary to prevent damage to the asphalt pavement cover. See Section 3.2.1.2 for specific design criteria.

Should traffic patterns increase beyond the limits used as performance criteria for the asphalt pavement or if other site conditions change from conditions described, the cover will be modified where necessary in accordance with the O&M plan and the Unified Facilities Criteria, UFC 3-250-18FA "General Provisions and Geometric Design for Roads, Streets, Walks, and Open Storage Areas." The UFC document describes criteria for construction for roads and other asphalt pavement surfaces designed to withstand significant vehicular traffic (Department of Defense [DoD] 2006). Any modifications could include additional layers of AC, removal of AC, or addition of aggregate base course (ABC) and placement of a thicker layer of AC. Modifications would be required only for the specific areas that would receive the increased traffic — for instance, an entryway or site throughway — and would not be required site wide. Additionally, traffic provisions such as signs and traffic markings may be required, depending on the amount and type of traffic expected.

A full inspection of the site conditions was conducted as part of this RD to assess the site and to develop the remedy. Historically, the site had been predominantly paved with AC; however, much of this surfacing material has weathered beyond repair or has been removed during the extensive excavations site wide and was not replaced. The majority of the original AC has been removed or disrupted by excavation, excessive degradation, and other activities at the site. The AC that remains and is exposed is heavily stressed with significant fatigue cracking, which compromises the durability of the cover and is likely beyond cost effective repair. Additionally, much of the remaining AC is covered by a layer of soil and gravel that has been deposited and compacted over time; this deposition would be difficult to remove to recover and repair the existing surface.

The following photographs are representative of the general conditions of the existing ground surface at Parcel B.

Location: Parcel B between Building 128 and Building 123
Facing: Southeast
Date: 9/3/09

Location: Parcel B between Building 125 and Building 128
Facing: East
Date: 9/3/09

The newly constructed asphalt pavement cover will extend between the existing buildings over the site to prevent contact with the potentially contaminated soil beneath. The asphalt pavement cover will consist of a minimum 4 inches of ABC material and a minimum 2 inches of an AC wear surface, for a total cover thickness of 6 inches. Existing surface features that prevent human contact with underlying soil, such as concrete pads, fire hydrants, and utilities, will be incorporated into the final asphalt pavement cover. Existing building foundations are considered part of the durable cover and are described in Section 3.2.3. Asphalt pavement will extend up to these features, blocking the human exposure pathway to underlying soil. Refer to the following sections for greater detail on the materials and the construction of the asphalt pavement.

3.2.1.1 Initial Site Grading and Compaction

Parcel B is generally flat, but some grading of the existing surface is required after unsound existing pavement and unsuitable existing soil have been removed. The site will be graded after the contaminated soil hotspot removals and subsequent filling of the excavations. The southwestern portion of the site is currently vegetated and more steeply sloped and will be addressed by the soil cover as described in Section 3.2.2 of this DBR. The existing grade will be used as the base foundation for the asphalt pavement cover, where appropriate. Some areas where soil deposition has occurred will be graded to establish smooth transitions across the site to construct the cover. Additionally, low-lying areas will be filled to minimize accumulation of storm water. Clean imported fill will be used in addition to the existing soil at the site in regrading. A borrow source assessment report will be submitted by the construction contractor, in accordance with the construction specifications, for approval by the Contracting Officer before the fill material is placed. Fill material will be screened in accordance with the "Information Advisory Clean Imported Fill" (DTSC 2001). Borrow source sampling requirements will be included in the RAWP, which will be submitted to the FFA signatories for approval.

Water flow patterns will be maintained toward the existing drainage channels. The 10-foot perimeter surrounding each site building will be sloped to a minimum 1 percent grade to drain storm water and minimize accumulation in the vicinity of the building foundations. Building entry points will not be obstructed by the final cover, and the final cover will not extend above the elevation of the foundation slab. The remainder of the site will have a minimum 0.5 percent slope to drain water toward the existing drainage channels and minimize accumulation of water over the site.

The ability of the subgrade to provide an adequate foundation to support the predicted traffic load is a consideration in the design of the cover. Soil across the site is predominantly engineered fill consisting of sand and gravel (ChaduxTt 2007). This soil type is a good subgrade for asphalt pavement construction without modification. A sandy or granular soil will support greater loading than would a clay material of the same thickness, which is subject to more deformation and compaction. Additionally, the site has historically been covered with an asphalt pavement of varying thickness, further indicating that the existing material is sufficient for construction of an asphalt pavement cover. Soils will be tested before construction and modified or removed and replaced as needed to provide a sufficient subgrade.

The granular subgrade will also drain moisture readily and exhibit a very low volumetric change when saturated, which will minimize differential heaving and weakening of the pavement structure.

Existing subgrade and imported fill used to meet the prescribed subgrade elevation will be compacted to a minimum density of 95 percent of the maximum density at ± 3 percent optimum moisture content based on modified Proctor density testing. The existing material will be tested to ensure its suitability and compacted as necessary prior to construction of the asphalt pavement. Existing site soils that cannot meet the classification or compaction requirements will be removed or modified by the construction contractor to meet the requirement. Meeting this density will resist differential settling over the site under the constructed cover, which could otherwise result in premature fatigue and cracking of the asphalt (Asphalt Institute [AI] 1983).

3.2.1.2 Asphalt Pavement Cover Components

The primary criterion of the design of the asphalt pavement cover is to prevent contact with the potentially contaminated soil beneath. The asphalt pavement cover over the site will include a minimum 4 inches of an untreated ABC material and a minimum 2 inches of an AC wear surface, which together constitutes a durable non-erodible cover. Clean imported fill and regrading over the site will be used to build up the existing ground surface where necessary to meet the prescribed foundation grade. Additionally, soil and sediment excavated from other portions of the site may be spread and compacted on site and used under the durable cover provided the soil or sediment has suitable engineering properties. The final total thickness of the asphalt pavement cover will be a minimum of 6 inches total, not including any fill that may be used as foundation below the cover.

Existing AC surfacing, where it is either intact or where it can be repaired, would also constitute a durable cover as defined by the amended ROD because it prevents contact with the underlying potentially contaminated soil. It is unlikely that there are significant areas of Parcel B where the existing AC could be incorporated into the final cover. However, the construction contractor may decide in the RAWP that will precede construction to incorporate some portion of the existing AC into the final cover. Any repair work, which includes patching, crack treatment, and asphalt overlays, must be conducted in compliance with State of California Department of Transportation standard specifications (CalTrans 2006, 2008) and the Department of Defense UFC (DoD 2001a, 2001b, and 2006). Parcel B has been thoroughly inspected and, based on the inspections and the amount of previous excavation work, it is assumed in this DBR that no portion of the existing asphalt pavement cover will be recoverable for use in the final cover. The assumption of new asphalt construction has also been used for estimating construction costs, as described in the cost opinion.

The secondary consideration for the design of the asphalt pavement cover is its ability to withstand the applied forces that could break down the cover and reduce its effectiveness in preventing contact with the potentially contaminated soil beneath throughout the post-closure period. In addition to natural forces, a design consideration for the durable cover over Parcel B is vehicle traffic, which will be restricted and primarily related to O&M activities. Breakdown of the AC will be minimal given the light traffic over the final AC wear surface and the negligible impact from storm water flow. Traffic over the site will be controlled by site and basewide security measures, and the cover will be monitored and repaired as part of the long-term O&M.

The asphalt pavement thickness and the methods for its construction are based on guidance from the Asphalt Institute (AI 1983) and correspondence with the Asphalt Pavement Association of California (2010). The thickness will be more than sufficient to withstand natural degradation and the anticipated light traffic loading associated with O&M.

An untreated ABC is appropriate for locations where the subgrade drainage conditions are suitable and where traffic loading is minimal, which are both the case for Parcel B. The untreated ABC is added and compacted directly onto the prepared subgrade. The base course will be added in maximum 6-inch lifts as needed and compacted to at least 95 percent of the maximum dry density based on modified Proctor testing to a final compacted thickness of at least 4 inches (AI 1983).

A prime tack coat of a low-viscosity liquid asphalt may be necessary over the untreated ABC. A tack coat promotes a good bond between the ABC and the AC overlay but is not necessary if the base course is sufficiently clean and has been freshly placed before the surface course is laid down (NAPA 2009). Selection of the ABC material and use of a tack coat will be at the discretion of the construction contractor and based on materials present and cost advantages at the time of construction in accordance with the construction specifications.

A hot mix AC will be added as the final surface course to a compressed thickness of at least 2 inches to complete the durable cover. Hot mix AC is composed of aggregate bound together into a solid by an asphaltic cement. Hot mix AC consists of 93 to 97 percent aggregate by weight and 3 to 7 percent asphaltic cement. The mix is generally manufactured at an off-site mixing plant and transported to the site for spreading by a mechanical spreader.

3.2.1.3 Other Design Considerations – Asphalt Pavement Cover

Material Volumes

Based on the thickness of the asphalt pavement cover, the following volumes of materials will be necessary: approximately 7,744 cubic yards of compacted AC and approximately 15,487 cubic yards of compacted ABC. Refer to Appendix A for the materials calculations. These volumes assume a cover of 6 inches across the site, not including the areas occupied by existing buildings.

Material Recycling

Use of recycled material, either imported or derived from the site, in construction of the new asphalt pavement cover may be an acceptable method for construction of the durable cover, so long as the minimum requirements for the cover material are met. The use of recycled material will be specified in the RAWP, which the construction contractor will submit for review and approval by the FFA signatories. The construction contractor will be required to demonstrate that use of this material will not have an adverse environmental or human health impact.

Construction Activities

The asphalt pavement cover will be constructed using standard construction equipment and practices in accordance with the existing controls for dust suppression as well as other environmental and storm water controls. All construction will meet the substantive requirements of a National Pollutant Discharge Elimination System (NPDES) permit and comply with the Regional Water Quality Control Board storm water pollution prevention plan. Best management practices (BMP) such as silt fences, wattles, and soil stabilization will be implemented and maintained to minimize erosion and control sediment migration during construction. Sediment and erosion control BMPs will be managed in accordance with the construction storm water pollution prevention plan that the construction contractor will submit before construction of the remedy. Dust control will meet the requirements of the San Francisco Bay Area Air Quality Management District (BAAQMD) Regulation 6, Rule 1 and existing HPS-specific criteria.

Material excavated during preparation of the soil cover and the revetment may be used as foundation material under the asphalt pavement cover, provided that the engineering properties of the soil or sediment are suitable. Refer to Section 3.3 for further description of these excavations along the shoreline. Soil excavated from hotspot removal locations will be disposed of off site and will not be reused.

The asphalt pavement cover will extend to the existing site boundary or to the revetment or the soil cover described in this DBR at all locations. A small portion of the seawall between Dry Docks 5 and 6 will require minor non-structural improvement to prevent loss of soil from the area. The seawall is currently open, and loss of soil has resulted in disturbance to the existing asphalt pavement cover. The open portion of the existing seawall will be sealed, and any void space behind the seawall will be backfilled to allow for construction and support of the asphalt pavement.

Drainage

Current drainage over the site is generally toward the northeast, which will be the condition over the final cover surface. Storm water will flow over land across the final cover and discharge primarily to the bay or to the existing drainage channels throughout the site. The existing site grade and drainage channels have been incorporated into the design, and no net change in the runoff patterns, flows, and volume from the existing condition is anticipated. Therefore, no hydrologic or hydraulic analysis was performed.

The drainage pattern for Parcel B is not expected to impair the surrounding drainage system or infrastructure because grade elevations and percent impervious surface are not expected to change significantly from the existing condition.

The asphalt pavement cover will be non-erodible, and overland flow will not erode the wear surface in any way that would reduce the effectiveness of the cover in preventing human contact with the underlying soil. AC is commonly used in public works applications such as curbs, gutters, swales, parking lots, and catch basin inlets. The application of AC at Parcel B is similar, and it is not anticipated to experience scour or erosion to any significant degree. Degradation will be monitored and repaired in accordance with the O&M plan.

Minimum 1 percent slopes will be required within 10 feet of all site buildings, including entrance thresholds, to drain water away from foundations. Minimum 0.5 percent slopes will be maintained throughout the remainder of the site where new asphalt pavement is being constructed. These minimum sloping requirements have been selected based on the existing topographic conditions across the site and to minimize the amount of cut and fill that would be required.

The selected slopes will drain storm water from the site, and any accumulated storm water will not diminish the effectiveness in preventing human exposure to contaminants in soil, which is the primary design criterion. Accumulated water will be monitored and any repairs made as part of O&M and in accordance with the HPS Storm Water Discharge Management Plan (MARRS Services, Inc. and MACTEC Engineering and Consulting, Inc. 2008) and the San Francisco Bay Regional Water Quality Control Board (Water Board) storm water pollution prevention plan.

The drainage channels will be paved to maintain the minimum cover thickness of 6 inches. Existing channel armoring material may be reused to meet the requirements for ABC or replaced at the discretion of the construction contractor.

Final Cover Survey

The surface of the final cover over the site will be surveyed after the project is complete to document the final cover elevations. Two permanent survey monuments will be installed on the cover surface and locations and elevations included with the final survey. Monuments will be a brass disk set in concrete and will be located and protected as necessary to prevent damage.

Site Security

A permanent security fence will run along the property boundary with non-Navy property and will be left in place after construction. Signs will be posted along the fence at approximately 200-foot spacing to warn against trespassing.

A security fence and signs are not requirements of the ROD, but they will be used to enhance the protectiveness of the remedy and would reduce long-term O&M in the event that site transfer did not occur.

Maintenance

Maintenance of the final AC wear surface will ensure durability and longevity of the remedy without replacement. Provisions for maintenance are provided in the O&M plan. Cracks and other degradation that may form will be repaired promptly in accordance with the O&M plan.

Generally, an asphalt pavement in an application similar to Parcel B can be expected to remain intact for 10 to 15 years, provided maintenance is completed promptly — that is, before initial surficial cracking or other signs of fatigue can extend into the base course and subsurface soils. Cracking in the asphaltic pavement material will be remedied promptly according the O&M plan. Given the minimal degradation and loading over the site from climatic factors or vehicle traffic, extensive maintenance and repair work is not expected. Loading from traffic will be the primary contributor to the breakdown of asphalt pavements. A security fence will remain in place after construction and traffic will be restricted, which will significantly reduce the rate of degradation.

3.2.2 Soil Cover

A soil cover will be constructed on the portions of Parcel B along the southwestern property boundary to prevent contact with COCs that may be present on this portion of the site (Figure 8). The primary criterion for the design of the cover is to prevent contact with potential COCs in underlying soil.

The soil cover will consist of a minimum 2-foot cover layer of clean imported soil in accordance with the amended ROD (ChaduxTt 2009a). Infiltration of water through the soil cover is not a concern for the site, but the cover will be constructed and graded to prevent storm water accumulation. The final surface of the cover will be vegetated to prevent erosion, which will ensure its long-term protectiveness. Specific design criteria are discussed in Sections 3.2.2.2 and 3.2.2.3.

A 2-foot-thick soil cover meets the requirements of the approved ROD for protectiveness and durability and is based on discussions with the BCT throughout the development of the ROD at Parcel B and other parcels at HPS (ChaduxTt 2009a). This thickness is also consistent with EPA guidance for human health risk assessment procedures for differentiating exposure scenarios for surface and subsurface soils. The soil cover is designed to resist erosion, prevent incidental human contact with underlying soil, and would require deliberate and destructive action to cause a breach.

This portion of Parcel B is approximately 3.5 acres and has slopes varying from 1 vertical to 5 horizontal (1V:5H or 20 percent) to 1V:2H (50 percent); it is therefore not practical to construct an asphalt pavement cover on this portion of the site. The following photograph is representative of the general conditions of the existing ground surface along the southern boundary of Parcel B where the soil cover will be constructed.

Location: Parcel B between Building 103 and Building 117
Facing: West
Date: 9/3/09

A conceptual cross section of the soil cover components is included as Figure 7, and the final cover grade is included in Figure 8. The following sections describe the components of the soil cover.

3.2.2.1 Initial Site Grading

Only minimal grading of the area will be conducted before the cover is built. The area is sloped, and extensive regrading would be difficult. The cover will be constructed with a minimum 2 feet of clean imported material over the existing material. The existing grade will be used to the extent possible to minimize excavation and maintain the existing surface water flow conditions.

Special consideration needs to be given to the boundary with the neighboring property to the southwest along Galvez Avenue and the access road (Donahue Street) northwest of the area. The 2-foot soil cover will abut the road along Galvez Avenue, and the road cannot be obstructed by the cover or the sloped portion of the cover where the cover will meet the existing grade. This same consideration is necessary for Donahue Street to the northeast. Therefore, excavations along these areas are needed to allow for the final cover to slope and meet the existing grade within the soil cover area while maintaining the minimum cover thickness of 2 feet. The soil cover will slope to meet the existing grade and retaining walls or other structures will not be used to transition from the cover to the existing grade. Figure 8 of this DBR shows the extent and grading of the final cover over this portion of the site.

The excavation soil from the above-described soil cover area boundaries will be returned to the site and ultimately placed under the asphalt pavement cover along with excavated soil and sediment encountered during construction of the revetment, as described in Section 3.3. An estimated 200 cubic yards (yd^3) of soil will be excavated along these boundaries to prepare the soil cover.

The areas upslope of retaining walls will be excavated as needed to allow the cover to slope downward to meet the top of the retaining wall while maintaining the minimum 2-foot soil thickness. Construction the soil cover in this manner will not require modification of the existing retaining wall.

3.2.2.2 Soil Cover

The soil cover over the site will be composed of clean imported fill material and will be a minimum of 2 feet thick over the area. The backfill soil sampling approach will be developed in accordance with the “Information Advisory Clean Imported Fill Material” (DTSC 2001). Borrow source sampling requirements will be included in the RAWP, which will be submitted to the FFA signatories for approval. The total volume of the soil cover layer is estimated at 11,293 bank cubic yards (bcy) or 14,700 loose cubic yards (lcy) considering a 1.3 bulking factor. Refer to Appendix B for the volumetric calculations of soil necessary for the cover remedy.

Soil compaction for the soil cover depends on depth from the final surface. All imported soils at depths greater than 0.5 foot below the final cover surface will be compacted to 85 percent or greater of the maximum density at ± 3 percent optimum moisture content, based on modified Proctor density testing. The construction of the cover will proceed in successive 6-inch lifts. The upper 0.5-foot portion of the soil cover will be compacted to not greater than 85 percent of the maximum dry density. This compaction scheme is based on U.S. Army Corps of Engineers technical guidance and optimizes slope stability with vegetative growth (U.S. Army Corps of Engineers 2001). These compaction densities may be difficult to achieve on the more steeply sloped portions of the site. Compaction methods in some areas will be at the discretion of the construction contractor. Compaction of the area will not affect the effectiveness of the remedy because infiltration of water is not being controlled and erosion will be prevented by the vegetation over the area.

The majority of the final cover toward the north will have average slopes of between 1V:5H, or about 20 percent, and 1V:2H, or about 50 percent. Final cover slopes throughout the site will be approximately equal to the current existing slopes.

The side portions of the cover will extend to meet the current existing grade at slopes not steeper than 1V:3H, or about 33 percent, along the perimeter of the site, and retaining walls will not be used to transition from the cover to the existing off-site grade.

3.2.2.3 Surface Drainage

The grading and the vegetative cover of the upper 0.5-foot layer of the final soil cover are designed to convey water as sheet flow over the majority of the surface as a means to dissipate the energy and flow of runoff caused by storm events. Channelized flow and existing drainage flow paths, volumes, and peak flow rates are anticipated to remain the same as existing conditions. Storm water originating on the soil cover will flow to the asphalt pavement cover and the existing storm drains on the site. Drainage will be monitored and remedied in accordance with the O&M plan. The natural topography of the area surrounding the site and the curbing and other drainage provisions along Galvez Avenue, Donahue Street, and Robinson Street observed during site inspections prevent significant run-on to the soil cover area and Parcel B in general. No drainage study outside the parcel boundary was conducted. The construction contractor may discover and correct any sources of run-on. Drainage provisions will be inspected and maintained during construction and the provisions that control runon and runoff will be inspected in accordance with the O&M plan.

The areas around the buildings in the vicinity of the soil cover will have an asphalt pavement apron to prevent infiltration of water and to eliminate the need for the 2 feet of soil cover to extend up the side of the buildings. Additionally, the apron will be sloped to prevent accumulation of water along the foundations and shed water toward the drainage provisions at the site during the post-closure period.

3.2.2.4 Erosion Control

The soil cover will be exposed to forces that primarily include erosion by wind and water. Erosion of the vegetated soil cover portion of the site has been estimated in this DBR. The calculation is included as Appendix C of this report. Erosion will be controlled by an erosion control blanket and a planting scheme that will use plants selected specifically to prevent erosion.

Erosion calculations have been completed for two cover scenarios anticipated for the vegetated soil cover portion of the project: (1) the period just after the cover is seeded and before the vegetation are established, which is considered the establishment period; and (2) the period after the vegetation becomes established over the cover, which is considered the long-term cover scenario. The design criterion for erosion is to limit it to 2 tons/acre/year, as suggested by the American Society of Civil Engineers for the design of landfill covers.

For the establishment period, it has been assumed that the ground cover would be completely bare and fully exposed to wind and water erosion without protection for the period just after the vegetation is planted over the soil cover. The establishment period is approximately 3 months; during this time, the construction contractor will be required to use erosion control practices (binders or geonetting) to prevent erosion and ensure the success of the vegetative cover, including developing irrigation schemes.

For the long-term vegetative cover scenario, it is assumed that the vegetative stand over the site is 80 percent covered, which will result in a rate of erosion below the 2 tons/acre/year criterion. The following seed mix, intended for survival without irrigation or significant maintenance after a 3-month establishment period, will be planted over the more steeply sloped portions of the soil cover along the slopes upgradient of the retaining walls. All species are native to California and this or similar seed mixes have been used on other portions of HPS.

Seed Mix (Steeper slopes)

Scientific Name	Common Name	Pounds/Acre
Bromus carinatus	California Brome	25
Hordeum brachyantherum	Meadow Barley	10
Vulpia microstachys	Small Fescue	6
Trifolium willdenovii	Tomcat Clover	4
Escholzia californica	California Poppy	1.5

A site-specific plant mix, described below will be used to minimize erosion for the remainder of the soil cover area over the shallower slopes.

The following planting mix, intended for survival without irrigation or significant maintenance after a 6-month establishment period, will be planted over the majority of the soil cover area. This mix has been selected for erosion and fire resistance. Plant selection involved several criteria and include, in order of importance:

1. Native plant to Bay Area
1. Erosion control
1. Fire resistance
1. Drought tolerance
2. Presence in ecosystem
3. Lack of invasiveness
4. Aesthetics

A criterion with the same level of importance means that any candidate plant must satisfy all these criteria. In other words, a plant that is present in the ecosystem (level 2) but did not satisfy any level 1 criterion could not be chosen.

Several resources were used to identify candidate plants. These resources include "Effects of Erosion Control Treatments on Native Plant and Ryegrass Establishment" (CalTrans Storm Water Program 2003); "University of California, Irvine Green and Gold Plan, A Summary of Campus Landscape Planning" (UC Irvine 2000); "Defensible Space Landscaping in the Urban/Wildland Interface: A compilation of fire performance ratings of residential landscape plants" (University of California Forest Products Laboratory 1997); "Plants with a Favorable Fire Performance Rating" (Diablo Firesafe Council 2010); and "Shoreline Plants — A Landscape Guide for the San Francisco Bay" (San Francisco Bay Conservation and Development Commission [BCDC] 2007).

A multi-pass screening operation reduced the list of candidate plants. Annual and perennial grasses were not considered based on their generally poor fire resistance. The final selection was made based on local availability, variety of species, and dominance of one species over another. In general, the beach and wood strawberry are dense groundcovers that spread with runners. Few groundcover varieties, except for annual grasses, can compete with the strawberry's dense mat. The poppy and lupine are slightly taller and will persist among the strawberry. They add variety and color. The plants selected are found in the table below.

Plant Mix (Shallower slopes)

Scientific Name	Common Name	Plant Mix Ratio
Escholzia californica	California Poppy	1
Fragaria chiloensis	Beach Strawberry	1
Lupinus variicolor	Many Colored Lupine	1

The plant mix ratio of 1 indicates equal quantities of each species will be used. The plants will be distributed equally along the slope. A biodegradable erosion control blanket will be used during the establishment period to minimize erosion of the soil cover. Irrigation during the establishment period will be necessary to ensure the success of the ground cover.

3.2.2.5 Other Design Considerations – Soil Cover

Final Cover Survey

The surface of the final soil cover will be surveyed after the project is complete to document the final cover elevations. Two permanent survey monuments will be installed on the soil cover and locations and elevations included with the final survey. Monuments will be a brass disk set in concrete and will be located and protected as necessary to prevent damage.

Site Security

A permanent fence will be installed and maintained along the soil cover portion of the site where the soil cover abuts the off-site non-Navy property. Signs will be posted along the fence at approximately 200-foot spacing to warn against trespassing and the hazards associated with the site.

A security fence and signs are not requirements of the ROD, but they will be used to enhance the protectiveness of the remedy and would reduce long-term O&M in the event that site transfer did not occur.

Construction Activities

Soil cover construction work will be completed using standard construction equipment and practices in accordance with the existing controls for dust suppression as well as other environmental and storm water controls. All construction will meet the substantive requirements of an NPDES permit and comply with the Water Board storm water pollution prevention plan. BMPs such as silt fences, wattles, and soil stabilization will be implemented and maintained to minimize erosion and control sediment migration during construction. Sediment and erosion control BMPs will be managed in accordance with the construction storm water pollution prevention plan that the construction contractor will submit before construction of the remedy. Dust control will meet the requirements of the San Francisco BAAQMD Regulation 6, Rule 1 and existing HPS-specific criteria.

Material excavated during preparation of the soil cover may be used as foundation material under the asphalt pavement cover, provided that the engineering properties of the soil are suitable.

3.2.3 Existing Building Foundations

The existing building foundations over the site, where intact and in good condition, constitute a durable cover as described in the amended ROD (ChaduxTt 2009a). The existing building foundations are considered a component of the durable cover because they are a physical barrier that prevents human contact with the potentially contaminated soil beneath. Access to crawl spaces will be blocked to prevent human contact with site soils.

Concrete pads and other monolithic items not associated with specific buildings can be incorporated into the final durable cover so long as they either meet or are repaired to the same conditions as the building foundations, as described in Section 3.2.3.2. Concrete pads are present in limited areas across the site.

Building details have not been included as part of this design because the buildings themselves will not be modified from their current condition unless repair of the foundation is necessary. Buildings will be secured to prevent unauthorized access and monitored as part of the O&M for the remedy. Under a future Navy site ownership scenario, the buildings over the site would not be occupied.

3.2.3.1 Inspection of Building Foundations

All site buildings have been inspected to identify areas within the buildings or along the exterior where the current condition of the foundation would require repair to prevent contact with underlying soil and to be considered durable. The buildings themselves not including the foundations are not considered part of the durable cover and were not inspected for structural integrity.

Building foundation inspections consisted of systematically walking and observing interior foundational areas, excluding crawl spaces. The exteriors of buildings that have exposed slab foundations or foundation walls were inspected in a similar manner. Generally, the building foundations were observed to be in good condition with few signs of wear or damage. However, needed repairs were noted and will be addressed during construction of the durable cover, as indicated on the construction drawings.

The following conditions were noted during the inspection, and the construction contractor will be required to make repairs or modifications as part of the remedy, including preventing access to areas below the buildings.

- Buildings 103, 104, 117, and 109 are elevated on support stilts above the existing grade, and the area beneath the buildings and existing soil are accessible from outside the building.
- Portions of Building 120 have a false floor or an accessible crawl space below the foundation floor.
- Floor drain or other contaminated soil removal actions were conducted at Buildings 113, 113A, 123, 128, 130, and 146. These excavations were backfilled with gravel to meet the surrounding grade.

3.2.3.2 Repair of Building Foundations

Building foundations will be repaired as part of the final remedy at the site. The construction contractor will be required to reinspect the buildings before construction to confirm the repairs and make additional repairs if necessary. Cracking in foundations was not observed during the building inspections but may exist in some buildings and would require repair by the construction contractor.

Ongoing inspection of the foundations and crawl spaces after the remedy has been implemented will be conducted as part of the O&M of the site and is summarized in the O&M plan.

The following summarizes the repairs to the foundations expected to be necessary that were observed during the inspections.

- Cracks larger than 1/4-inch will be filled with grout or mortar and tapered at the surface into the surrounding foundation. A foundation with cracks smaller than 1/4-inch would remain protective and prevent contact with the underlying soils. Cracks smaller than 1/4-inch will be noted in the inspection and observed over time and repaired in accordance with the O&M plan if expansion of the crack is observed.

- Gaps or other large openings in the foundation that expose soil or where soil could be accessible will be repaired. These areas may include concrete coring locations that have not been repaired, previous excavations that have not been returned to grade, or locations where the existing slab has been damaged. These areas will be filled with clean imported fill as necessary and completed to surface with unreinforced Portland cement concrete.

- The construction contractor will seal any entries to crawl spaces or other access points to areas below building foundations to prevent access and exposure to soil. These access points will be sealed using galvanized wire mesh secured to the building foundations or supports.

- All refuse, debris, or other loose materials will be removed from all buildings on site and disposed of in accordance with applicable standards.

- The construction contractor will seal or fill openings to any abandoned utility corridor, trench, chase, or conduit.

3.3 REVETMENT

A revetment is a facing of armor material such as stone or concrete that is intended to protect a shoreline from erosion or slope failure. The primary physical components of the revetment are the armoring material, the toe, the crest, and the filter layer. The armoring material is selected and sized based on the forces that will act on the structure, such as water currents, wave action, and gravity. The extent of the revetment, or the elevations of the toe and crest, is based on the expected high and low water conditions, significant wave heights, and wave runup on the structure. The filter layer is set between the armoring material and the underlying soil or engineered fill and is intended to allow water to pass while supporting the structure and preventing erosion of the underlying soil and sediment.

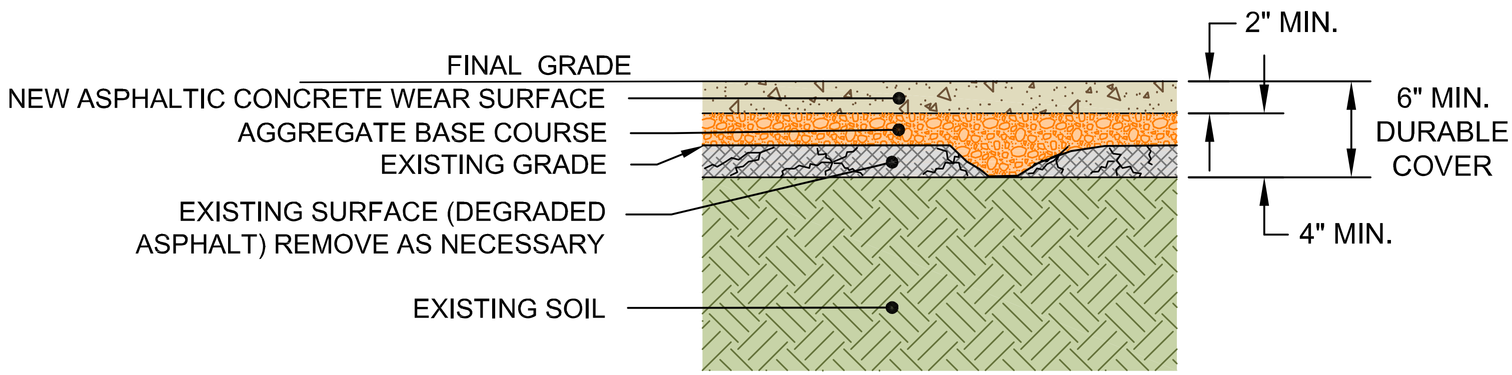
The design of the revetment for Parcel B differs slightly from traditional revetment designs. These differences are related to the additional function in containment of the contaminated soil and sediment of the Parcel B site and protection of human and ecological health — similar to the provisions of the durable cover over the landward portion of the site. The following list summarizes the primary design criteria that were used in developing the revetment design:

- The impact of anticipated maximum wave energy.

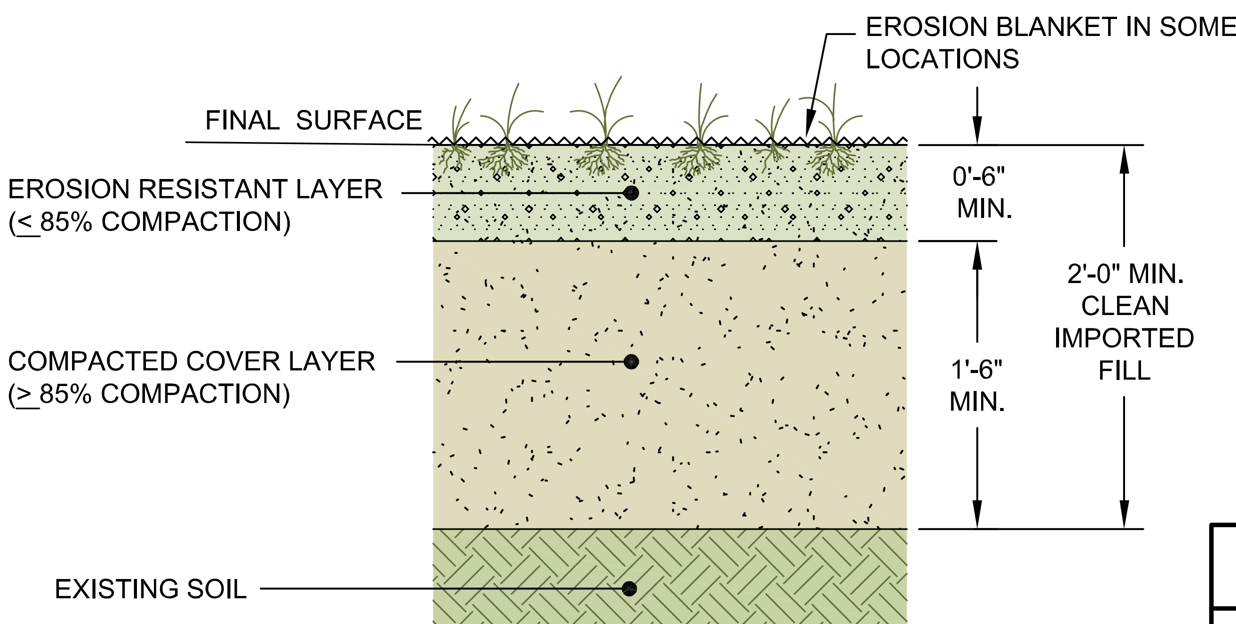
- Water levels from tidal fluctuations and potential sea level rise.

- Encapsulation of all potentially contaminated sediment; thus, the revetment needs to extend to the off-shore property boundary.

R:\Navy\Hunters Point\Parcel B\Remedial Design\ Figure 7 Cover Components.dwg 12/03/2010 deborah.ford DN



6" ASPHALT PAVEMENT COVER



2' SOIL COVER

NOT TO SCALE

ChaduxTt JV

Consulting Engineers and Scientists

Hunters Point Shipyard, San Francisco, California

Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 7

CONCEPTUAL COVER CROSS SECTIONS

Design Basis Report for Parcel B

Radiological cleanup standards and the USEPA PRG Calculator
Hunters Point Naval Shipyard, San Francisco, California

In December, 2016, EPA updated its Preliminary Remediation Goal (PRG) Calculator for radiological contamination. The User's Guide for the PRG Calculator recommends using site-specific factors for a realistic scenario for exposure. On February 3, 2017, EPA Health Physicist Lyndsey Nguyen entered the concentrations for the Hunters Point Naval Shipyard Radionuclides of Concern (RoC's) at the 2006 Action Memo release criteria, which were adopted by all the RODs as Remediation Goals (RG's). Below is a table showing risks for all Hunters Point Naval Shipayrd RoC's from the current RG's for future use scenario as described below. All of following risks fall within the NCP risk range of 10^-4 to 10^-6. In addition, this table also shows calculated Preliminary Remediation Goal concentrations that would be associated with a 10^-4 risk in the same realistic scenario.

Residential use PRGs for Soil, Site-Specific realistic scenario
Hunters Point Naval Shipyard, San Francisco, CA

Isotope	Preliminary Remediation Goal (PRG) (pCi/g) at 10^-4 risk	Total Risk at ROD RGs
*Secular Equilibrium PRG for Am-241	7.16E+00	1.90E-05
*Secular Equilibrium PRG for Co-60	1.14E+00	3.16E-06
*Secular Equilibrium PRG for Cs-137	5.65E+00	2.00E-06
*Secular Equilibrium PRG for Eu-152	2.63E+00	4.94E-06
*Secular Equilibrium PRG for Eu-154	2.43E+00	9.46E-06
*Secular Equilibrium PRG for H-3	-	-
*Secular Equilibrium PRG for Pu-239	6.21E+00	4.17E-05
*Secular Equilibrium PRG for Ra-226	1.69E+00	5.90E-05
*Secular Equilibrium PRG for Sr-90	7.46E+02	4.43E-08
*Secular Equilibrium PRG for Th-232	1.24E+00	1.36E-04
*Secular Equilibrium PRG for U-235	6.21E+00	3.14E-06
Total Risk if all Radionuclides of Concern were present at RG levels in same location		2.78E-04

Output generated 03FEB2017:16:09:33

For each radionuclide, the following parameters were determined to be the most realistic scenario for calculating the above risk values:

1. The Durable Cover can be 2 feet of soil, 6" of asphalt, or a building foundation. (See attached relevant excerpts from the Parcel B RD). Attached are Lyndsey's calculations

showing that a 6” thick asphalt cover has equivalent gamma shielding to a 25 cm soil cover. The PRG calculator only allows entries in 10 cm increments, so she entered 20 cm, which may be roughly equivalent to 4.8” asphalt cover, to be conservative.

2. Residential scenario in which the resident lives in a home that has a generic default building foundation on top of that 4.8” thick asphalt cover.
3. Zero inhalation due to the durable cover
4. Zero ingestion of homegrown produce due to the institutional control prohibition
5. A survey unit is up to 1,000 m2. Section 4.10.5 of the Users Guide states: “The RAGS/HHEM Part B model assumes that an individual is exposed to a source geometry that is effectively an infinite slab. The concept of an infinite slab means that the thickness of the contaminated zone and its aerial extent are so large that it behaves as if it were infinite in its physical dimensions. In practice, soil contaminated to a depth greater than about 15 cm and with an aerial extent greater than about 1,000 m2 will create a radiation field comparable to that of an infinite slab. (U.S. EPA. 2000a)” (Lyndsey noted, however, “when I ran the calculator with 10,000 m2 for ACF [area correction factor] and changed it to the maximum, I got different results.”) To ensure that an infinite plane is taken into account in the risk calculations, a 1,000,000 m2 ACF was used.

Here’s the link to the PRG Calculator Users Guide with details: https://epa-prgs.ornl.gov/radionuclides/prg_guide.html. Attached is the PRG run that shows risks from exposures to individual radionuclides in secular equilibrium at the concentrations of the current RG’s. In a particular survey unit, EPA uses the current version of the PRG Calculator to estimate the combined risk of residual concentrations of all radionuclides of concern (ROC’s) to arrive at a total risk, which is then compared to the NCP risk range. The above table shows that even if all Radionuclides of Concern at the Hunters Point Naval Shipyard were present within a single location, the combined risk would be 2.78 E-4. As a practical matter, usually a given survey unit contains two to four Radionuclides of Concern, so the total risk would fall below this level.

Please feel free to contact Lyndsey directly:

Lyndsey Nguyen
Environmental Response Team-Las Vegas
Phone: 702.784.8018
Cell: 702-373-3756
Email: Nguyen.Lyndsey@EPA.gov

Residential use PRGs for Soil, Site-Specific realistic scenario
Hunters Point Naval Shipyard, San Francisco, CA

Isotope	Preliminary Remediation Goal (PRG) (pCi/g) at 10^-4 risk	Total Risk at ROD RGs
*Secular Equilibrium PRG for Am-241	7.16E+00	1.90E-05
*Secular Equilibrium PRG for Co-60	1.14E+00	3.16E-06
*Secular Equilibrium PRG for Cs-137	5.65E+00	2.00E-06
*Secular Equilibrium PRG for Eu-152	2.63E+00	4.94E-06
*Secular Equilibrium PRG for Eu-154	2.43E+00	9.46E-06
*Secular Equilibrium PRG for H-3	-	-
*Secular Equilibrium PRG for Pu-239	6.21E+00	4.17E-05
*Secular Equilibrium PRG for Ra-226	1.69E+00	5.90E-05
*Secular Equilibrium PRG for Sr-90	7.46E+02	4.43E-08
*Secular Equilibrium PRG for Th-232	1.24E+00	1.36E-04
*Secular Equilibrium PRG for U-235	6.21E+00	3.14E-06
Total Risk if all Radionuclides of Concern were present at RG levels in same location		2.78E-04

Output generated 03FEB2017:16:09:33

Site-Specific
Resident Equation Inputs for Soil

Variable	Value
TR (target cancer risk) unitless	0.0001
t_{res} (time - resident) yr	26
ED_{res} (exposure duration - resident) yr	26
ET_{res} (exposure time - resident) hr/day	24
ET_{res-c} (exposure time - resident child) hr/day	24
ET_{res-a} (exposure time - resident adult) hr/day	24
ET_{res-i} (exposure time - indoor resident) hr/day	16.416
ET_{res-o} (exposure time - outdoor resident) hr/day	1.752
ED_{res-c} (exposure duration - resident child) yr	6
ED_{res-a} (exposure duration - resident adult) yr	20
EF_{res} (exposure frequency - resident) day/yr	350
EF_{res-c} (exposure frequency - resident child) day/yr	350
EF_{res-a} (exposure frequency - resident adult) day/yr	350
IRS_{res-a} (soil intake rate - resident adult) mg/day	0
IRS_{res-c} (soil intake rate - resident child) mg/day	0
IRA_{res-a} (inhalation rate - resident adult) m^3/day	0
IRA_{res-c} (inhalation rate - resident child) m^3/day	0
$IFS_{res-adj}$ (age-adjusted soil ingestion factor - resident) mg	0
$IFA_{res-adj}$ (age-adjusted soil inhalation factor - resident) m^3	0
GSF_i (gamma shielding factor - indoor) unitless	0.4
Site area for ACF (area correction factor) m^2	1000029
Cover thickness for GSF_o (gamma shielding factor) cm	20
$IRAP_{res-a}$ (apple ingestion rate - resident adult) g/day	73.7
$IRAP_{res-c}$ (apple ingestion rate - resident child) g/day	72.2
$IFAP_{res-adj}$ (age-adjusted apple ingestion factor) g	0
$IRCI_{res-a}$ (citrus ingestion rate - resident adult) g/day	309.4
$IRCI_{res-c}$ (citrus ingestion rate - resident child) g/day	194.1
$IFCI_{res-adj}$ (age-adjusted citrus ingestion factor) g	0
$IRBE_{res-a}$ (berry ingestion rate - resident adult) g/day	35.4
$IRBE_{res-c}$ (berry ingestion rate - resident child) g/day	23.9
$IFBE_{res-adj}$ (age-adjusted berry ingestion factor) g	0
$IRPC_{res-a}$ (peach ingestion rate - resident adult) g/day	115.7
$IRPC_{res-c}$ (peach ingestion rate - resident child) g/day	111.4
$IFPC_{res-adj}$ (age-adjusted peach ingestion factor) g	0

Output generated 03FEB2017:16:09:33

Site-Specific

Resident Equation Inputs for Soil

Variable	Value
$IRPR_{res-a}$ (pear ingestion rate - resident adult) g/day	51.9
$IRPR_{res-c}$ (pear ingestion rate - resident child) g/day	66.7
$IFPR_{res-adj}$ (age-adjusted pear ingestion factor) g	0
$IRST_{res-a}$ (strawberry ingestion rate - resident adult) g/day	40.5
$IRST_{res-c}$ (strawberry ingestion rate - resident child) g/day	25.3
$IFST_{res-adj}$ (age-adjusted strawberry ingestion factor) g	0
$IRAS_{res-a}$ (asparagus ingestion rate - resident adult) g/day	39.3
$IRAS_{res-c}$ (asparagus ingestion rate - resident child) g/day	12.0
$IFAS_{res-adj}$ (age-adjusted asparagus ingestion factor) g	0
$IRBT_{res-a}$ (beet ingestion rate - resident adult) g/day	33.9
$IRBT_{res-c}$ (beet ingestion rate - resident child) g/day	3.9
$IFBT_{res-adj}$ (age-adjusted beet ingestion factor) g	0
$IRBR_{res-a}$ (broccoli ingestion rate - resident adult) g/day	32.0
$IRBR_{res-c}$ (broccoli ingestion rate - resident child) g/day	13.1
$IFBR_{res-adj}$ (age-adjusted broccoli ingestion factor) g	0
$IRCB_{res-a}$ (cabbage ingestion rate - resident adult) g/day	92.1
$IRCB_{res-c}$ (cabbage ingestion rate - resident child) g/day	12.3
$IFCB_{res-adj}$ (age-adjusted cabbage ingestion factor) g	0
$IRCR_{res-a}$ (carrot ingestion rate - resident adult) g/day	27.3
$IRCR_{res-c}$ (carrot ingestion rate - resident child) g/day	14.9
$IFCR_{res-adj}$ (age-adjusted carrot ingestion factor) g	0
$IRCO_{res-a}$ (corn ingestion rate - resident adult) g/day	59.8
$IRCO_{res-c}$ (corn ingestion rate - resident child) g/day	23.8
$IFCO_{res-adj}$ (age-adjusted corn ingestion factor) g	0
$IRCU_{res-a}$ (cucumber ingestion rate - resident adult) g/day	82.4
$IRCU_{res-c}$ (cucumber ingestion rate - resident child) g/day	25.4
$IFCU_{res-adj}$ (age-adjusted cucumber ingestion factor) g	0
$IRLE_{res-a}$ (lettuce ingestion rate - resident adult) g/day	37.5
$IRLE_{res-c}$ (lettuce ingestion rate - resident child) g/day	4.2
$IFLE_{res-adj}$ (age-adjusted lettuce ingestion factor) g	0
$IRLI_{res-a}$ (lima bean ingestion rate - resident adult) g/day	33.8
$IRLI_{res-c}$ (lima bean ingestion rate - resident child) g/day	6.5
$IFLI_{res-adj}$ (age-adjusted lima bean ingestion factor) g	0
$IROK_{res-a}$ (okra ingestion rate - resident adult) g/day	30.2

Site-Specific

Resident Equation Inputs for Soil

Variable	Value
$IROK_{res-c}$ (okra ingestion rate - resident child) g/day	5.3
$IFOK_{res-adj}$ (age-adjusted okra ingestion factor) g	0
$IRON_{res-a}$ (onion ingestion rate - resident adult) g/day	21.8
$IRON_{res-c}$ (onion ingestion rate - resident child) g/day	5.8
$IFON_{res-adj}$ (age-adjusted onion ingestion factor) g	0
$IRPE_{res-a}$ (pea ingestion rate - resident adult) g/day	35.4
$IRPE_{res-c}$ (pea ingestion rate - resident child) g/day	32.1
$IFPE_{res-adj}$ (age-adjusted pea ingestion factor) g	0
$IRPU_{res-a}$ (pumpkin ingestion rate - resident adult) g/day	64.8
$IRPU_{res-c}$ (pumpkin ingestion rate - resident child) g/day	45.2
$IFPU_{res-adj}$ (age-adjusted pumpkin ingestion factor) g	0
$IRSN_{res-a}$ (snap bean ingestion rate - resident adult) g/day	53.9
$IRSN_{res-c}$ (snap bean ingestion rate - resident child) g/day	27.3
$IFSN_{res-adj}$ (age-adjusted snap bean ingestion factor) g	0
$IRTO_{res-a}$ (tomato ingestion rate - resident adult) g/day	80.3
$IRTO_{res-c}$ (tomato ingestion rate - resident child) g/day	29.7
$IFTO_{res-adj}$ (age-adjusted tomato ingestion factor) g	0
$IRPT_{res-a}$ (potato ingestion rate - resident adult) g/day	127.8
$IRPT_{res-c}$ (potato ingestion rate - resident child) g/day	51.7
$IFPT_{res-adj}$ (age-adjusted potato ingestion factor) g	0
$IRRI_{res-a}$ (rice ingestion rate - resident adult) g/day	73.2
$IRRI_{res-c}$ (rice ingestion rate - resident child) g/day	28.8
$IFRI_{res-adj}$ (age-adjusted rice ingestion factor) g	0
$IRCG_{res-a}$ (cereal grain ingestion rate - resident adult) g/day	76.0
$IRCG_{res-c}$ (cereal grain ingestion rate - resident child) g/day	38.0
$IFCG_{res-adj}$ (age-adjusted cereal grain ingestion factor) g	611800
$CF_{res-produce}$ (contaminated plant fraction) unitless	1
$CF_{res-apple}$ (contaminated apple fraction) unitless	1
$CF_{res-citrus}$ (contaminated citrus fraction) unitless	1
$CF_{res-berry}$ (contaminated berry fraction) unitless	1
$CF_{res-peach}$ (contaminated peach fraction) unitless	1
$CF_{res-pear}$ (contaminated pear fraction) unitless	1
$CF_{res-strawberry}$ (contaminated strawberry fraction) unitless	1
$CF_{res-asparagus}$ (contaminated asparagus fraction) unitless	1

Site-Specific
Resident Equation Inputs for Soil

Variable	Value
$CF_{res\text{-}beet}$ (contaminated beet fraction) unitless	1
$CF_{res\text{-}broccoli}$ (contaminated broccoli fraction) unitless	1
$CF_{res\text{-}cabbage}$ (contaminated cabbage fraction) unitless	1
$CF_{res\text{-}carrot}$ (contaminated carrot fraction) unitless	1
$CF_{res\text{-}corn}$ (contaminated corn fraction) unitless	1
$CF_{res\text{-}cucumber}$ (contaminated cucumber fraction) unitless	1
$CF_{res\text{-}lettuce}$ (contaminated lettuce fraction) unitless	1
$CF_{res\text{-}lima\ bean}$ (contaminated lima bean fraction) unitless	1
$CF_{res\text{-}okra}$ (contaminated okra fraction) unitless	1
$CF_{res\text{-}onion}$ (contaminated onion fraction) unitless	1
$CF_{res\text{-}pea}$ (contaminated pea fraction) unitless	1
$CF_{res\text{-}pumpkin}$ (contaminated pumpkin fraction) unitless	1
$CF_{res\text{-}snap\ bean}$ (contaminated snap bean fraction) unitless	1
$CF_{res\text{-}tomato}$ (contaminated tomato fraction) unitless	1
$CF_{res\text{-}potato}$ (contaminated potato fraction) unitless	1
$CF_{res\text{-}rice}$ (contaminated rice fraction) unitless	1
$CF_{res\text{-}cereal\ grain}$ (contaminated cereal grain fraction) unitless	1
MLF_{apple} (apple mass loading factor) unitless	.000160
MLF_{citrus} (citrus mass loading factor) unitless	.000157
MLF_{berry} (berry mass loading factor) unitless	.000166
MLF_{peach} (peach mass loading factor) unitless	.000150
MLF_{pear} (pear mass loading factor) unitless	.000160
$MLF_{strawberry}$ (strawberry mass loading factor) unitless	.0000800
$MLF_{asparagus}$ (asparagus mass loading factor) unitless	.0000790
MLF_{beet} (beet mass loading factor) unitless	.000138
$MLF_{broccoli}$ (broccoli mass loading factor) unitless	.00101
$MLF_{cabbage}$ (cabbage mass loading factor) unitless	.000105
MLF_{carrot} (carrot mass loading factor) unitless	.0000970
MLF_{corn} (corn mass loading factor) unitless	.000145
$MLF_{cucumber}$ (cucumber mass loading factor) unitless	.0000400
$MLF_{lettuce}$ (lettuce mass loading factor) unitless	.0135
$MLF_{lima\ bean}$ (lima bean mass loading factor) unitless	.00383
MLF_{okra} (okra mass loading factor) unitless	.0000800
MLF_{onion} (onion mass loading factor) unitless	.0000970

Resident Equation Inputs for Soil

Variable	Value
MLF_{pea} (pea mass loading factor) unitless	.000178
$MLF_{pumpkin}$ (pumpkin mass loading factor) unitless	.0000580
$MLF_{snap\ bean}$ (snap bean mass loading factor) unitless	.00500
MLF_{tomato} (tomato mass loading factor) unitless	.00159
MLF_{potato} (potato mass loading factor) unitless	.000210
MLF_{rice} (rice mass loading factor) unitless	.250
$MLF_{cereal\ grain}$ (cereal grain mass loading factor) unitless	.250
TR (target cancer risk) unitless	0.0001
ED_{res-c} (exposure duration - resident child) yr	0
ED_{res-a} (exposure duration - resident adult) yr	0
EF_{res-c} (exposure frequency - resident child) day/yr	0
EF_{res-a} (exposure frequency - resident adult) day/yr	0
City (Climate Zone)	26
A_s (acres)	500
Q/C_{wp} (g/m^2-s per kg/m^3)	31.690869932192
PEF (particulate emission factor) m^3/kg	9986605274.2569
A (PEF Dispersion Constant)	13.8139
B (PEF Dispersion Constant)	20.1624
C (PEF Dispersion Constant)	234.2869
V (fraction of vegetative cover) unitless	0.8
U_m (mean annual wind speed) m/s	3.89
U_t (equivalent threshold value)	11.32
F(x) (function dependant on U_m/U_t) unitless	0.0391

Site-Specific
Resident PRGs for Soil

Isotope	Ingestion PRG (pCi/g)	Inhalation PRG (pCi/g)	External Exposure PRG (pCi/g)	Produce Consumption PRG (pCi/g)	Total PRG (pCi/g)
**Secular Equilibrium PRG for Am-241*	-	-	*7.16E+00*	-	*7.16E+00*
**Secular Equilibrium PRG for Co-60*	-	-	*1.14E+00*	-	*1.14E+00*
**Secular Equilibrium PRG for Cs-137*	-	-	*5.65E+00*	-	*5.65E+00*
**Secular Equilibrium PRG for Eu-152*	-	-	*2.63E+00*	-	*2.63E+00*
**Secular Equilibrium PRG for Eu-154*	-	-	*2.43E+00*	-	*2.43E+00*
**Secular Equilibrium PRG for H-3*	-	-	-	-	-
**Secular Equilibrium PRG for Pu-239*	-	-	*6.21E+00*	-	*6.21E+00*
**Secular Equilibrium PRG for Ra-226*	-	-	*1.69E+00*	-	*1.69E+00*
**Secular Equilibrium PRG for Sr-90*	-	-	*7.46E+02*	-	*7.46E+02*
**Secular Equilibrium PRG for Th-232*	-	-	*1.24E+00*	-	*1.24E+00*
**Secular Equilibrium PRG for U-235*	-	-	*6.21E+00*	-	*6.21E+00*

Site-Specific
Resident Risk for Soil

Isotope	Ingestion Risk	Inhalation Risk	External Exposure Risk	Produce Consumption Risk	Total Risk
*Secular Equilibrium Risk for Am-241	-	-	1.90E-05	-	1.90E-05
*Secular Equilibrium Risk for Co-60	-	-	3.16E-06	-	3.16E-06
*Secular Equilibrium Risk for Cs-137	-	-	2.00E-06	-	2.00E-06
*Secular Equilibrium Risk for Eu-152	-	-	4.94E-06	-	4.94E-06
*Secular Equilibrium Risk for Eu-154	-	-	9.46E-06	-	9.46E-06
*Secular Equilibrium Risk for H-3	-	-	-	-	-
*Secular Equilibrium Risk for Pu-239	-	-	4.17E-05	-	4.17E-05
*Secular Equilibrium Risk for Ra-226	-	-	5.90E-05	-	5.90E-05
*Secular Equilibrium Risk for Sr-90	-	-	4.43E-08	-	4.43E-08
*Secular Equilibrium Risk for Th-232	-	-	1.36E-04	-	1.36E-04
*Secular Equilibrium Risk for U-235	-	-	3.14E-06	-	3.14E-06
*Total Risk	-	-	2.78E-04	-	2.78E-04